The effect of perceived risk of false diagnosis on preferences for COVID-19 testing: Evidence from the United States

Tomás Rossetti & Ricardo Daziano
HEALTH

THE PLAN THAT COULD GIVE US OUR LIVES BACK

The U.S. has never had enough coronavirus tests. Now a group of epidemiologists, economists, and dreamers is plotting a new strategy to defeat the virus, even before a vaccine is found.

By Robinson Meyer and Alexis C. Madrigal
Rapid tests can vastly increase testing capacity...
...but they provide false results at a higher rate
The main downside of rapid tests is that they are less sensitive and specific – which means that they produce more false negative and false positive results.
Pricing information is vital in the United States

How Much Should It Cost to Get Tested for COVID-19?

U.S. rules allow labs to charge whatever they want for tests, and companies are making billions as the latest spike in cases strains testing availability

By Adam Tanner
Published January 6, 2022 | Updated January 11, 2022

Your payment summary

<table>
<thead>
<tr>
<th>Patient</th>
<th>Provider</th>
<th>Amount</th>
<th>Sent to</th>
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<td>Tomas (self)</td>
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<td>MinuteClinic Diagnostics</td>
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<td><strong>Total:</strong></td>
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<td><strong>$59.00</strong></td>
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<th>Patient</th>
<th>Provider</th>
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Your payment summary

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<th>Patient</th>
<th>Provider</th>
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Pricing is even more important after the federal health emergency ended

COVID-19 Coverage in SHP Is Changing

David Williams <dw82@cornell.edu>

to me ▼

On May 12th, 2023, the federal COVID-19 emergency ended.

Treatment and testing for COVID-19 is still covered under the Student Health Plan, however cost-sharing for these services has changed. Here’s how:

- **COVID-19 lab tests**: You will pay a copay, coinsurance, or deductible at in-network locations. Any of benefits for details on cost-sharing.
  - Office visits related to COVID-19 will also follow normal plan cost-share.
  - COVID-19 vaccines, including boosters: You will still pay $0 for the vaccine at in-network locations.

- **COVID-19 at-home test kits, also known as over-the-counter (OTC) test kits**: You will pay the retail cost of the test kits.
  - Anti-viral medications or treatments, like Paxlovid: Copays may apply.

Need help?

- For questions regarding pharmacy benefits, call Optum at 856-868-1677.
- For questions about office visits and inpatient treatment, call Aetna at 800-859-8475.
- For general questions, email us at studentbenefits@cornell.edu.

Best wishes for spring!
WTP for better accuracy is not straightforward

There are several effects that make this difficult:

1. **Strategic ignorance**: Individuals tend to avoid information that could cause a cost

2. **Perceived probabilities**: People are bad at assessing risk. Classic example: purchase of lottery tickets

3. **Probability neglect**: When strong emotions are in play, people tend to focus on the outcome and not on the probability (Sunstein, 2003)

The health literature does not tend to account for these effects
Objectives

1. Obtain willingness to pay for COVID-19 test attributes
2. Compare objective and perceived risks of false diagnosis
3. Identify groups more likely to skip testing
Methods

Choice experiment to collect data in the USA

We used a mixed logit model to make inference on test feature preferences using Bayesian techniques (Hamiltonian Monte Carlo) with appropriate transformations of probabilities of false positive and negative results.
Data collection

All experiments also had an opt-out alternative

Treatments: rate of wrong diagnosis (“3 out of 100 people without COVID-19 wrongly result positive”) vs correct diagnosis (“97 out of 100 people without COVID-19 correctly result negative”)
<table>
<thead>
<tr>
<th>Test A</th>
<th>Test B</th>
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<tbody>
<tr>
<td>Out of pocket cost</td>
<td>Out of pocket cost</td>
</tr>
<tr>
<td>$75</td>
<td>FREE</td>
</tr>
<tr>
<td>saliva</td>
<td>swab – deep in nasal cavity</td>
</tr>
<tr>
<td>results in</td>
<td>results in</td>
</tr>
<tr>
<td>5 minutes</td>
<td>72 hours</td>
</tr>
<tr>
<td>Sample collected at</td>
<td>Sample collected at</td>
</tr>
<tr>
<td>drive-through</td>
<td>home</td>
</tr>
<tr>
<td>3 out of 100 people without COVID-19</td>
<td>1 out of 100 people without COVID-19</td>
</tr>
<tr>
<td>wrongly result positive</td>
<td>wrongly result positive</td>
</tr>
<tr>
<td>15 out of 100 people with COVID-19</td>
<td>7 out of 100 people with COVID-19</td>
</tr>
<tr>
<td>wrongly result negative</td>
<td>wrongly result negative</td>
</tr>
</tbody>
</table>
Methods: Bayesian estimation

The objective of Bayesian inference is to update beliefs by collecting data.

\[
\Pr(\Theta|y) = \frac{\Pr(y|\Theta) \cdot \Pr(\Theta)}{\Pr(y)} = \frac{\text{likelihood} \cdot \text{prior}}{\text{marginal}}
\]

\[
\propto \Pr(y|\Theta) \cdot \Pr(\Theta)
\]

No conjugates for choice models: approximate posterior sampling for inference

We used **Hamiltonian Monte Carlo**
What is Hamiltonian Monte Carlo?

Let’s assume we want to draw samples from $p(\theta)$ (usually a posterior distribution) and $U(\theta) = -\log p(\theta)$ is a transformation of it.
What is Hamiltonian Monte Carlo?

Metropolis-Hastings will create draws using a random walk.
What is Hamiltonian Monte Carlo?

HMC is like throwing a hockey puck in a random direction with random strength.
What are the advantages of Hamiltonian Monte Carlo?

**Metropolis-Hastings**

- Does not require information about the gradient of the posterior

**But:**

- Can take very long to explore the distribution
- The proposal distribution is very inefficient
- Can get stuck in a local minimum

**Hamiltonian Monte Carlo**

- Can explore the distribution more quickly with larger steps, so requires fewer iterations to stabilize
- Breaks auto-correlation much better, so even fewer draws are required
- It can break “energy barriers” to jump from one local minimum to another
- Even though the cost of one iteration is higher, the total cost in practice is still usually lower
The model

\[ v_{ijt} = \begin{cases} 
\mu_w (\alpha_{jw} + \tilde{x}_{ijt}' \beta_i) & j \in \{\text{test A, test B}\} \\
\mu_w (d_i' \delta_w) & j = \text{opt out}
\end{cases} \]

where \( \tilde{x}_{ijtk} = \begin{cases} 
 w (x_{ijtk} ; \lambda_f, \gamma_f) & k \in \{\text{false positive, false negative}\} \\
x_{ijtk} & \text{otherwise}
\end{cases} \)

\[ \beta_i \overset{iid}{\sim} N_K (\bar{\beta}, \Sigma) \]
Generative process

\[ \alpha, \bar{\beta}, \delta \overset{iid}{\sim} N(0, 2) \]
\[ \mu \overset{iid}{\sim} \text{FN}^+(1, 2) \]
\[ \lambda, \gamma \overset{iid}{\sim} \text{FN}^+(1, 2) \]
\[ \sigma \overset{iid}{\sim} \text{FN}^+(0, 2) \]
\[ \Omega_L \sim \text{LKJ}(4) \]
\[ v_{it} | \alpha, \bar{\beta}, \lambda, \gamma, \sigma, \Omega_L \sim N \left( \alpha + \tilde{X}_{it} \bar{\beta}, \tilde{X}_{it} \Omega_L \text{diag}(\sigma)^2 \Omega_L' \tilde{X}_{it}' \right) \quad \forall i, t, j \in \{\text{test A, test B}\} \]
\[ y_{it} | v_{it} \sim \text{MNL}(v_{it}) \quad \forall i, t \]
Methods: Transformation of probabilities

We took ideas from prospect theory. Some common transformations:

- $w(p) = p^\gamma$
- $w(p) = p^\gamma / (p^\gamma + (1 - p)^\gamma)^{1/\gamma}$ (Tversky and Kahneman, 1992)
Methods: Transformation of probabilities

We used the Prelec transformation because it is more flexible and only sets non-negative constraints on its parameters.

\[ w(p; \alpha, \gamma) = \exp(-\alpha(-\ln p)^\gamma) \]
Median WTP estimates are mostly in line with our expectations
There is substantial preference heterogeneity—possibly due to non-compensatory behavior.
There are large deviations between objective and perceived probabilities
These deviations make WTP highly non-linear for test improvements.

The utilities are

\[ u = \cdots + \beta_{i}^{FP} \cdot \exp(-\alpha(- \ln p^{FP})^\gamma) + \beta_{i}^{FN} \cdot \exp(-\alpha(- \ln p^{FN})^\gamma) + \beta_i^\$ \cdot \text{price} + \cdots \]

The willingness to pay to reduce \( p^{FP} \) is

\[
WTP = \frac{\partial u/\partial p^{FP}}{\partial u/\partial \text{price}} \\
= \frac{\beta_{i}^{FP} \cdot (\partial \exp(-\alpha(- \ln p^{FP})^\gamma)/\partial p^{FP})}{\beta_i^\$} = \frac{\beta^F_{i} P}{\beta_i^\$} 
\]
These deviations make WTP highly non-linear for test improvements.
**Case study**: How much are people willing to pay for a rapid test?

<table>
<thead>
<tr>
<th></th>
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<th>Rapid test</th>
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<tr>
<td>Out of pocket cost</td>
<td>$0</td>
<td>Dependent var.</td>
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<tr>
<td>Swab type</td>
<td>Deep</td>
<td>Frontal</td>
</tr>
<tr>
<td>Waiting time</td>
<td>2 days</td>
<td>10 minutes</td>
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<tr>
<td>Lab type</td>
<td>Walk-in clinic</td>
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<tr>
<td>False positive rate</td>
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<td>Independent var.</td>
</tr>
<tr>
<td>False negative rate</td>
<td>0%</td>
<td>Independent var.</td>
</tr>
</tbody>
</table>
Most available tests have a positive median WTP.
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Most available tests have a positive median WTP
Most available tests have a positive median WTP.
Labs have an incentive to improve mediocre false diagnosis rates
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Labs have an incentive to improve mediocre false diagnosis rates.
In summary

1. On average, people prefer faster, less invasive tests

2. There is a larger sensitivity to false positive than negative results, which suggests there is some strategic ignorance

3. Perceived probabilities of false diagnosis deviate considerably from objective ones (low probabilities are underestimated, medium to high ones are overestimated)

4. There is a high variance in WTP for rapid tests, but more accurate ones have better chances of outperforming PCR tests
Thank you!
Acknowledgments

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References


